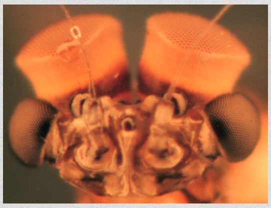
Sensory ecology: Matching receivers to signals & "matched filters"

A/Prof Jan M Hemmi
School of Biological Sciences
University of Western Australia



An eye

An ear

A nose

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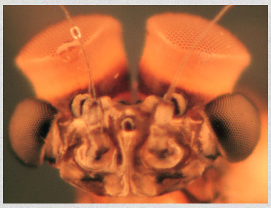
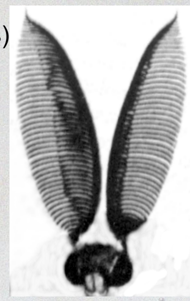
Sensory Diversity: Why is it there?



An eye

- Evolutionary history
- The body (size, energy, etc)
- The environment
- Signals (Communication & others)
- Information - Behaviour

An ear



A nose

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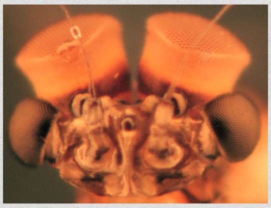
Sensory Diversity: And how do we find out what is driving it?

- Comparative approaches
- Psychophysics
- Ecology - Behaviour
- Robotics



An eye

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Information and the organisation of behaviour

The sensory-behaviour **feedback** loop

The functional context determines the relevance of information

Behaviour affects the timing and the accuracy of information

Neural mechanisms

Behavioural options/ needs

Constrain options

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Automation

What are the drivers?

- Cost
- Operating environment
- Size
- Complexity / current solutions
- Task (need to solve a task)

Bioinspired robotics

Sciencemag.org

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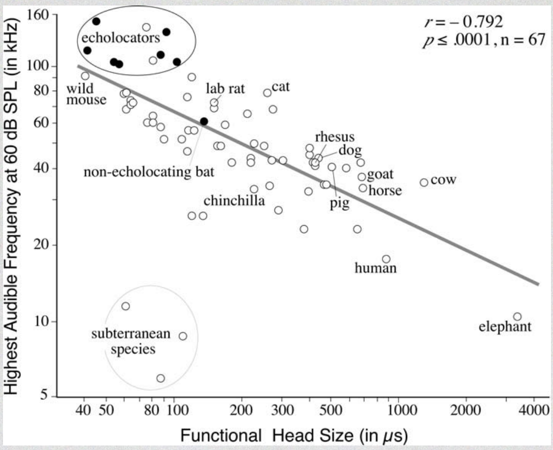
Body size: High-frequency hearing in mammals

(matching receivers to signals)



(Time it takes for sound to move around the head)

- Allometric relationship

$$\mathbf{y} = \mathbf{k}x^{a}$$

or in its logarithmic form, plotted here:

$$\log \mathbf{y} = \mathbf{a} \log x + \log \mathrm{k}$$

- Driven by sound localization demands: Δt and Δfi (spectral differences)
- Small heads produce smaller Δt and smaller Δfi

Heffner & Heffner 2008

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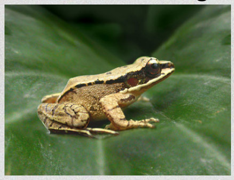
Environmental impacts: Evolution of frog calls

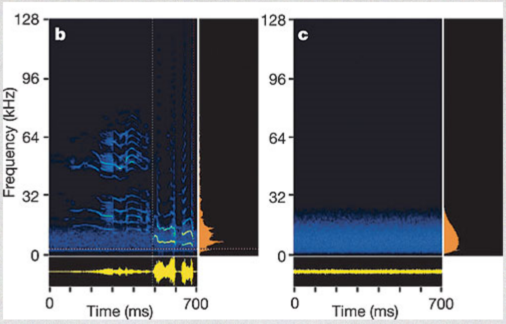
(matching signals to environments)

Imagine being a frog near a waterfall

Ultrasonic frog



Sonogram of concave-eared torrent frog



Call structure

Noise structure

Feng et al 2006 Nature

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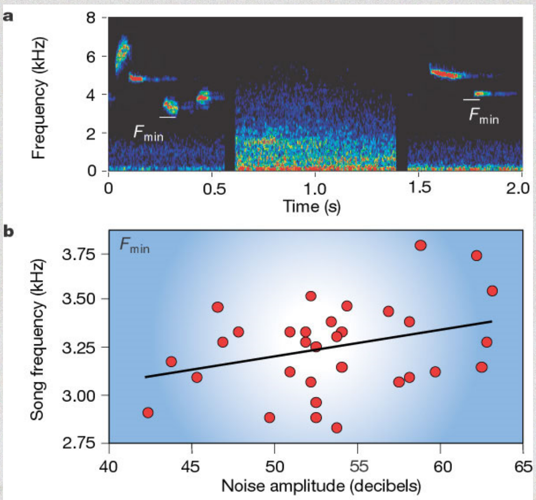
Environmental impacts: Variability in bird calls

(matching signals to environments)

Correlation between song frequency and ambient noise in urban great tits.



Left: call in quite environment

Middle: urban noise

Right: call in noisy environment

Great tits increase their lowest frequency in noisy environments (presumably to conserve energy)

Slabbekoorn and Peet 2003 Nature

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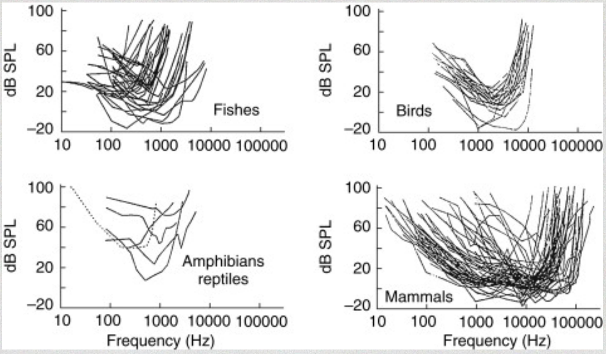
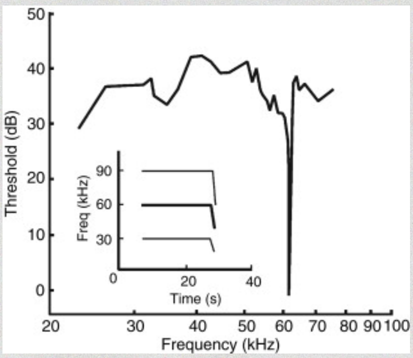
Tuning curves for different animal groups



Why is there more variability in some groups than others?

Gridi-Papp & Narins, Sensory Ecology of Hearing in The Senses 2008

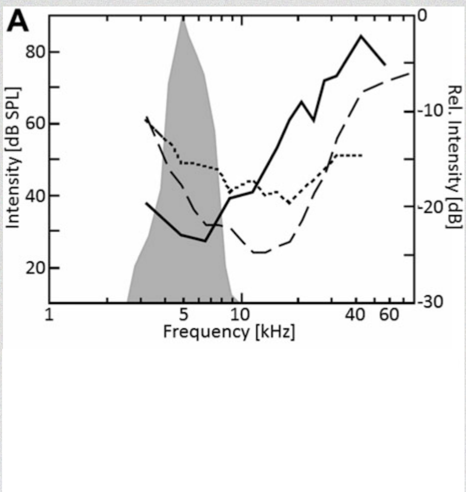
Matching of sensitivity and signal: Call frequency & hearing sensitivity in a bat



Cochlear audiogram of Parnell's mustached bat (*Pteronotus parnellii*). Insert: A schematic spectrogram of the echolocation call of the same species.

Gridi-Papp & Narins, Sensory Ecology of Hearing in The Senses 2008

Tuning of calling hearing sensitivity: Call frequency & hearing in a katydid (*Sciarasaga quadrata*)



Grey: call frequency
Dashed line: hearing sensitivity

Why call at lower frequencies than is optimal for hearing?

Romer 2016 Matched Filters in Insect Audition

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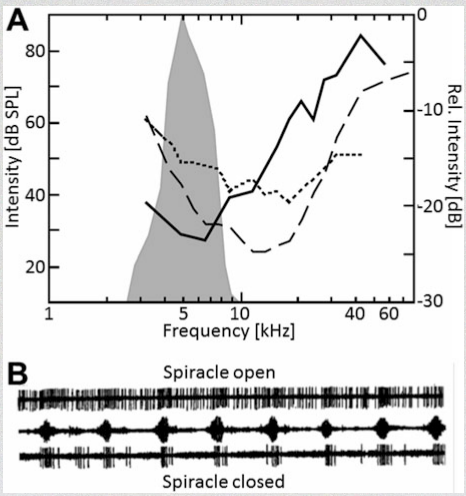
Tuning of calling hearing sensitivity: Call frequency & hearing in a katydid (*Sciarasaga quadrata*)



Why call at lower frequencies than is optimal for hearing?

Grey: call frequency
Dashed line: hearing sensitivity
Dotted line: hearing sensitivity of parasitoid fly
Solid line: hearing sensitivity with Spiracle closed

Neural responses to the call of a conspecific (middle) under two conditions

Römer 2016 Matched Filters in Insect Audition

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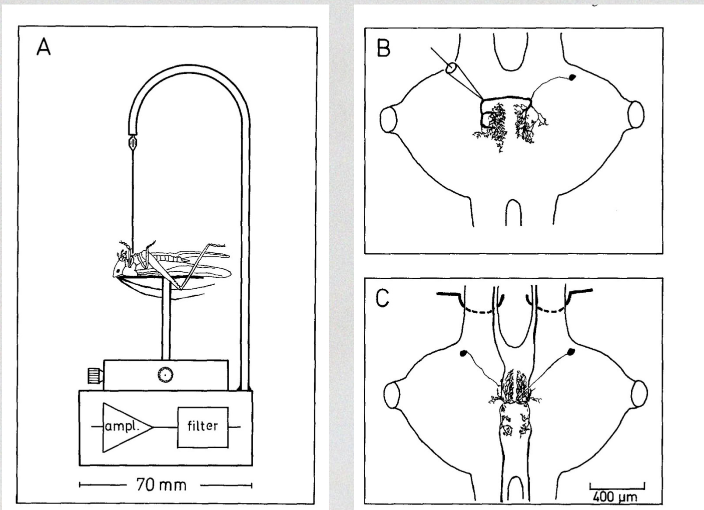
How to measure environmental impacts on perception (transmission properties of env.)



Electrophysiological recording from Omega neurons

Rheinlaender & Römer 1986

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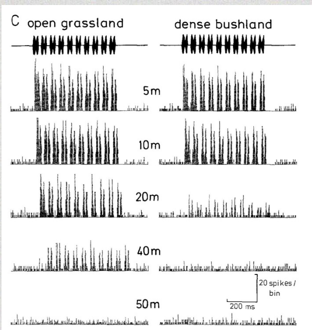
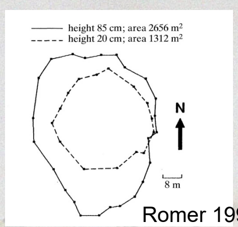
Environment: Active range & information content of cricket calls

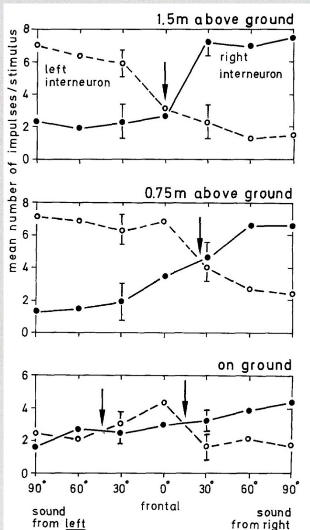


The receiver's neural response drops differently with distance, depending on habitat



The signal's active range increases with the signaller's height above ground

Romer 1993



Directional information improves with receiver's height above ground

Rheinlaender Romer 1986

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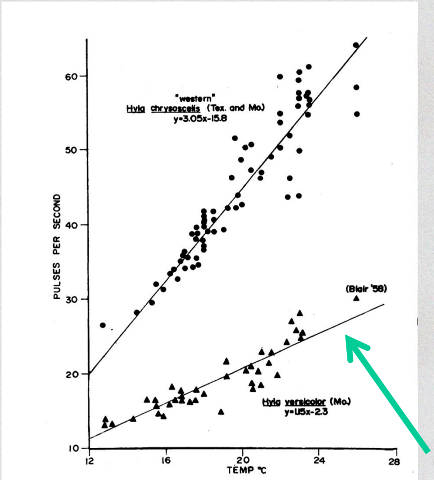
Gray tree frogs:

Temperature dependence of calls & hearing – a matched filter?



Male call rate for two sympatric species

	15/sec	24/sec
16 deg	12	0
24 deg	1	10

Female response rate (preference) for two synthetic calls at two temperatures

Gray tree frogs

Gerhardt 1978 Science

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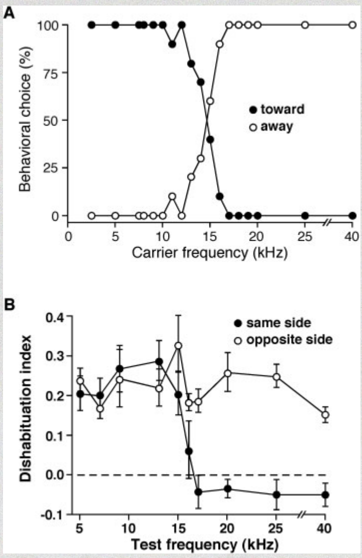
A matched auditory filter in flying crickets



Proportion of crickets moving toward or away from an artificial "song" as a function of the song's carrier frequency. All crickets responded to all frequencies.

Natural song is approximately 4.7 kHz

All but one bat species use calling frequencies of more than 15kHz

Wyttenbach and Farris 2004

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